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Disease Evaluation: Westfir Transplant Nursery 1976

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DISEASE EVALUATION: WESTFIR TRANSPLANT NURSERY 1976

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INTRODUCTION AND SITE DESCRIPTION

The Westfir Transplant Nursery, Oakridge Ranger District, Willamette National Forest, is located in T21S, R2E, sec. 12, 0.8 km west of Hemlock, Oregon. The nursery, situated on a bench above the North Fork of the Middle Fork of the Willamette River, is roughly rectangular in shape and currently encompasses 6.8 ha. Elevation varies from 307 to 312 m above sea level. A major drainage crosses about 2/3 of the nursery in roughly a north-south direction, and several smaller drainages and low spots occur throughout the beds, especially in the northwest corner.

The nursery was established in the fall of 1959, and the first crop of 600,000 seedlings was planted on 2.5 ha in the spring of 1960. Prior to establishment of the nursery, most of the site was abandoned pasture land, though a small portion was second growth Douglas-fir forest. Evidence suggests that one or more homesteads occupied the nursery site in the early 1900's.

The Westfir Nursery currently produces between 3 and 4 million 1-1 and 2-1 seedlings annually for outplanting on southwestern Oregon National Forests. Most of these are Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco), but some noble fir (*Abies procera* Rehd.) and ponderosa pine (*Pinus ponderosa* Laws) are also grown.

For several years, considerable mortality and foliage chlorosis have occurred in transplant beds at Westfir. In 1975, 1,800,000 of 3,300,000 transplanted seedlings died during the season or were discarded at the time of lifting. Evidence also suggests that outplanting success of Westfir stock was lower than that of stock produced by other nurseries. Loss due to seedling mortality, culling, and poor field survival has become a matter of major concern.

The Westfir Nursery was one of five Oregon and Washington nurseries in which Pratt, et al[1/] found *Phytophthora* spp. causing an apparently severe root rot of Douglas-fir seedlings. The possibility that Phytophthora root rot might be a major cause of damage at Westfir has been suggested.

EVALUATION OBJECTIVES

The present evaluations were instituted to investigate scope of seedling problems in the nursery, role of diseases in contributing to them, and potential usefulness of two fungicides in managing diseases at Westfir. Three projects were conducted: (a) An investigation of in-nursery mortality, with the specific objectives of measuring amount and sequential occurrence of seedling death and determining, if possible, causes of mortality; (b) an evaluation of chlorotic tree outplanting success, with the specific objective of determining whether culling of chlorotic seedlings exhibiting otherwise good characteristics (full crowns and normal root systems) is a desirable and necessary practice; and (c) a fungicide treatment test, with the specific objectives of evaluating and comparing the efficacy of a broad spectrum fungicide and a fungicide specific for watermolds as protectants against root rots in the nursery. Soil drench and root dip methods of application for each fungicide were also compared.

MATERIALS AND METHODS

In-Nursery Mortality

In May 1976, at the time of transplanting, 117 3.3 m X 1.2 m plots were established in 180 beds in the Westfir Nursery. A multistage sampling design was employed. Beds to be sampled were selected systematically, and plot locations in each were determined randomly. A lightweight frame (Figure 1) was used to divide each plot into 10 subunits (5 selected randomly per plot) and these were the actual units sampled (Figure 2).

Plots were examined monthly until November 1976. Seedlings that had died between each sampling visit were counted and collected. Isolations from roots and lower stems of dead trees were made on potato dextrose, malt, and water agar. Fungi growing in culture were identified to determine the presence of possible pathogens.

Soil and tissue samples for nematode evaluation and nutrient analyses were collected at several locations in the nursery. Nematode testing was done at the Oregon State University Plant Clinic and nutrient analyses in the

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1/Pratt, R. G., L. F. Roth, E. M. Hansen, and W. D. Ostrofsky. 1976. Identity and pathogenicity of species of Phytophthora causing root rot of Douglas-fir in the Pacific Northwest. Phyopathology 66:710-714.

Figure 1: Lightweight frame used to delineate sampling subunits.

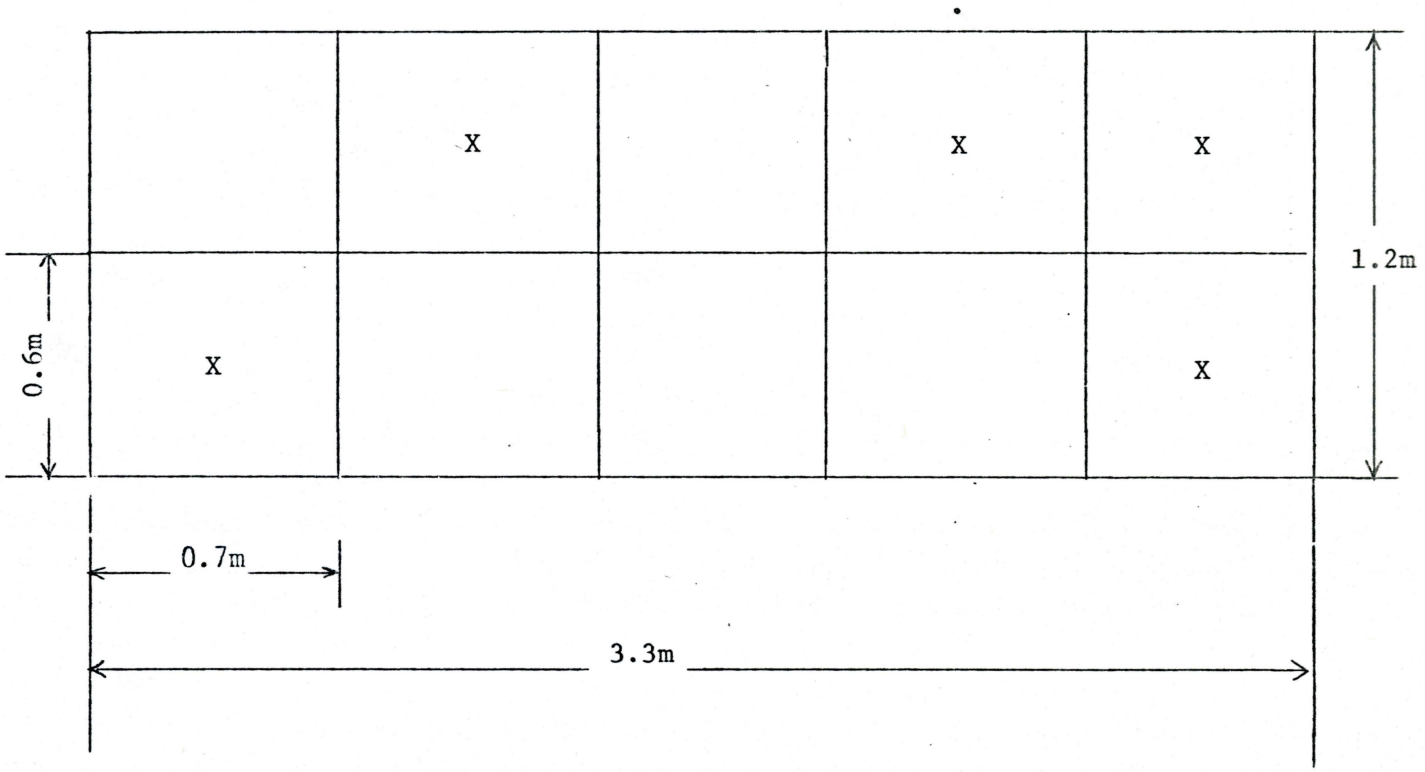

Figure 2: Plot layout for mortality survey. Five subplots chosen randomly (X) were the units sampled within each plot.

Soil Testing Laboratory at the same institution.

Chlorotic Tree Outplanting

In April 1976, 200 normal green and 200 chlorotic seedlings from Westfir Nursery were outplanted on the Oakridge Ranger District. Chlorotic seedlings had full crowns and normal-appearing root systems but were being discarded under then existing culling criteria.

Seedlings were planted by Forest Service crews using standard planting techniques. Fifty green and 50 chlorotic seedlings were planted in each of four locations. Planting sites varied considerably in quality. The poorest site was located on a steep slope with a south exposure, very shallow soil, and metamorphic parent material. The best site was on a flat plateau with deep soil of andesitic origin. At each planting location, green and chlorotic seedlings were planted in alternating rows of 10 trees each. Trees were planted at approximately 2 m spacing. Care was taken to make the rows as similar as possible in prior site preparation, drainage, and aspect. Planting sites were visited monthly from May to November 1976, and again in February 1977. Dying trees were counted and collected. Isolations were made from lower stems and roots to ascertain cause of death. At the end of the evaluation, height, form, crown color, and survival rate were compared between chlorotic and normal seedlings.

Fungicide Evaluation

Two fungicides, Banrot and Truban, were tested.[2/] Banrot (a combination of 15 percent Terrazole and 25 percent Topsin M) is reportedly effective against many soil borne pathogens. Truban (Terrazole) is reportedly effective against watermolds. Application rates used for both fungicides were 168 grams/378 liters/304 meters^2 for soil drenches and 56 grams/378 liters for root dip solutions.

Eight evaluation series were established at different localities in the nursery. Each evaluation series was composed of 5 blocks, a sequence of Banrot root dip, Banrot soil drench, Truban root dip, Truban soil drench and untreated control (Figure 3). Within each evaluation series, the order of treatments was determined randomly. Each treatment block was approximately 7.6 m long. Buffer strips of at least 10 m were left between treatments to avoid spread of fungicide-treated soil from block to block during cultivation. Each treatment was located in a bed or adjacent beds containing stock from the same seed source. Fungicide

2/These fungicides were among several suggested by Dr. A. H. McCain, Extension Plant Pathologist, University of California, Berkeley.

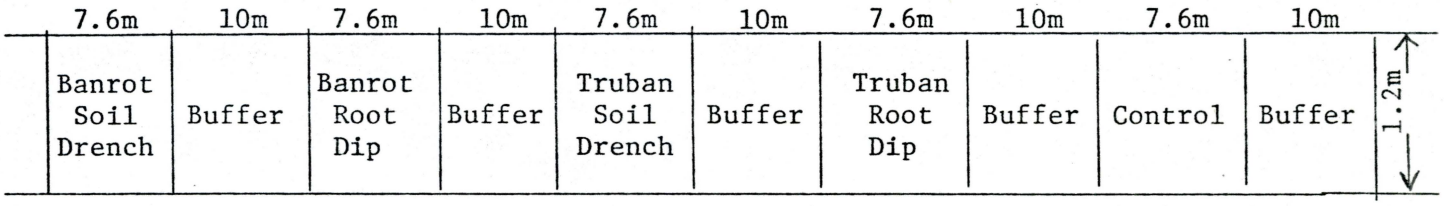

Figure 3: Fungicide treatment layout in nursery bed.

applications were done by Forest Insect and Disease Management staff and nursery personnel using nursery apparatus.

Permanent plots 3.3 m X 1.2 m were established in the center of each treatment block. Mortality in the plots was monitored in the manner previously described for monitoring in-nursery mortality. In November just before seedlings were lifted, a subsample of 20 living trees from each of the 40 treatment blocks (those closest to the corners of each sampling unit) was collected, and a dry weight root-to-top ratio was determined for each seedling. Proportion of culls in each treatment was also ascertained.

RESULTS

In-Nursery Mortality

From May to November 1976, loss due to death for all seedlings in the sample plots was 4.5 percent. Noble fir suffered 9.6 percent mortality, ponderosa pine 4.1 percent, and Douglas-fir 3.5 percent. There were two mortality peaks, one in June approximately two months after transplanting and another in September approximately five months after transplanting. Temporal sequence of mortality is shown in Figure 4.

Dying seedlings were concentrated in certain nursery beds. Some beds showed as high as 81 percent mortality while others exhibited no mortality whatsoever. Occurrence of mortality seemed to be irrespective of seed source or zone but rather was related to location in the nursery and/or treatment and condition of the seedling lot prior to transplanting. Of 22 plots that suffered in excess of 5 percent mortality, 18 percent were located in areas of poor drainage, 39 percent contained previously heeled-in seedlings, 11 percent contained seedlings that had been infected by storage mold fungi[3/], 11 percent contained seedlings that had been subjected to excessive temperatures previous to transplanting, 6 percent contained seedlings that had suffered frost damage prior to lifting and transplanting, and 6 percent exhibited evidence of mechanical damage at the time of transplanting.

Most isolations made from roots and stems of 644 dead seedlings produced no potentially pathogenic fungi, but *Fusarium* spp. were obtained from 9 percent and *Pythium* spp. from 10 percent of the seedlings. In some plots (2 percent of all plots) in poorly drained areas, *Phytophthora* spp. were readily isolated from chlorotic, declining seedlings with deteriorated root systems[4/] (Figure 5 and 6). Seedlings in these plots exhibited high

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3/Fungi isolated from stem and foliage samples of molded seedlings were *Botrytis* sp., *Arthrobotrys* sp., *Fusarium* sp., *Alternaria* sp., and *Penicillium* sp.

4/*Phytophthora* spp. isolated by Dr. Jay Julis, Oregon State University.

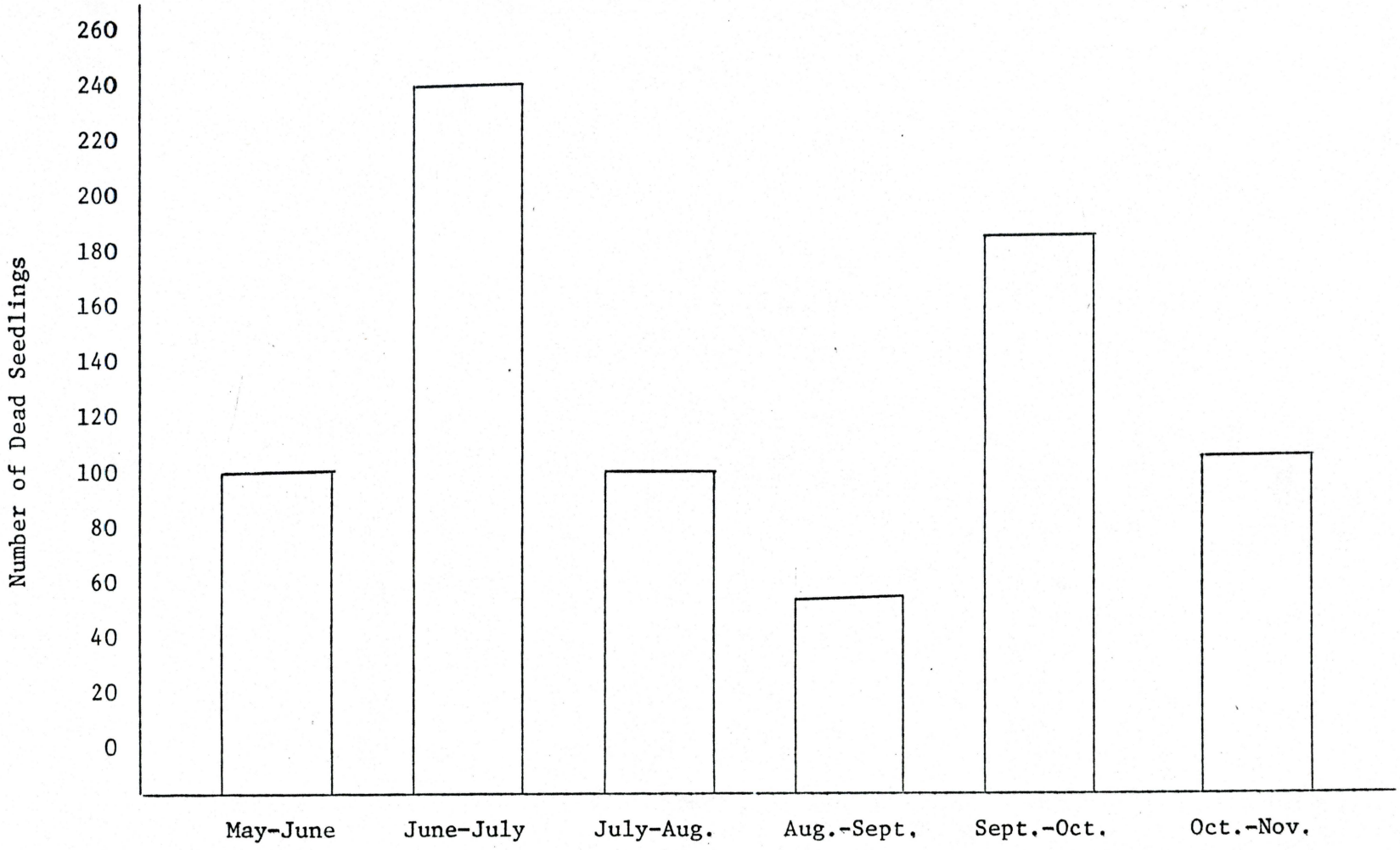

Figure 4: Temporal sequence of seedling mortality at Westfir Nursery during the 1976 growing season (585 0.7m X 0.6m plots).

Figure 5: Patch of declining seedlings in Westfir Nursery associated with poor drainage and *Phytophthora* infection.

Figure 6: Symptoms of infection by *Phytophthora* sp. on Douglas-fir seedlings from Westfir Nursery.

mortality levels that were assumed to be caused by Phytophthora root rot, though *Phytophthora* spp. could not be isolated from any dead seedlings. Evaluation of soil and root tissue samples from the nursery did not reveal any plant parasitic nematodes.

Analysis of nursery soils showed low phosphorous (.10 to .18 percent), calcium (.13 to .33 percent), and magnesium (.13 to .15 percent), and marginal nitrogen (1.5 to 1.8 percent) contents. Tissue analysis showed high to very high manganese (194 to 319 ppm) and iron (347 to 867 ppm) levels. Nutrient imbalances were most pronounced in poorly drained areas of the nursery.

Chlorotic Tree Outplanting

No significant differences emerged between survival rates of outplanted chlorotic and green seedlings. Lumping all sites together, 93 percent of the green seedlings and 90 percent of the chlorotic seedlings survived. A slight disparity in survival was noted on the most severe site, with green trees outsurviving chlorotic trees 84 percent to 68 percent. However, chlorotic seedlings outsurvived green trees on one of the better sites 100 percent to 96 percent. The two types of seedlings both showed 96 percent survival in the other two sites. No pathogenic fungi were isolated from roots of outplanted seedlings that died. Poor planting technique ("J rooting") was associated with almost all mortality.

There were no differences in amount of growth between green and chlorotic seedlings. Both types of seedlings showed a mean height increase of 0.6 cm between the time of outplanting in April 1976 and February 1977. Fifty-eight percent of the chlorotic seedlings attained color comparable to the green trees by February 1977 (Figure 7).

Fungicide Evaluation

Results of the fungicide tests are summarized in Table 1. Seedlings in Banrot treatments appeared to suffer less mortality than those in Truban treatments or controls. Seedlings dipped in Banrot appeared to suffer less than those grown in Banrot-drenched soil, but differences were small, and there was considerable variation within treatments. Analysis of variance showed differences to be nonsignificant at the .05 confidence level.

Mean root-to-top ratios for seedlings treated with both fungicides appeared to be higher than those for untreated control seedlings. Ratios for Banrot-treated seedlings appeared higher than those for Truban-treated seedlings. Root dip treatments with Truban resulted in a higher mean root-to-top ratios than soil drench treatments, and the reverse was true

Figure 7: Crown color comparison of outplanted green and chlorotic seedlings from Westfir Nursery after one growing season (seedlings with white flags were green, those with yellow flags chlorotic).

Fungicide	Method of Application	Mean % Mortality	Mean Root-to-Top Ratio
Banrot	Root Dip	1.7	0.55
	Soil Drench	2.4	0.59
	Both Methods	2.1	0.58
Truban	Root Dip	3.1	0.55
	Soil Drench	3.1	0.52
	Both Methods	3.1	0.53
Control	---	3.2	0.47

Table 1: Mortality and Root-to-Top Ratios of Fungicide-treated and untreated Douglas-fir seedlings, Westfir Nursery.

of Banrot. Again differences were small and variation within treatments great. Differences were not significant at the 0.05 confidence level.

DISCUSSION

Seedling loss in the Westfir Transplant Nursery during the 1976 growing season was considerably less than in 1975. Based on nursery records and plots monitored in this evaluation, overall mortality in 1976 was 4.5 percent and cull 20 percent. There are several probable reasons for this decreased loss including: (a) Less crowding of seedlings in 1976, (b) avoidance of transplanting in many of the most poorly drained parts of the nursery, (c) irrigation based on need rather than a prearranged schedule, and (d) a new fertilization program providing more nitrogen later in the season. Losses can be reduced further.

Seedling mortality at the Westfir Nursery appears to be caused by a complex of factors. Poor condition of some seedling lots at the time of transplanting is associated with much of the death. Many molded, previously injured, temperature damaged and/or heeled-in seedlings die within the first two months after transplanting and account for the mortality peak observed early in the season.

Nutrient imbalances in the nursery are also important in weakening and killing seedlings, especially in the more poorly drained areas. Iron and manganese excesses may be toxic or block uptake or metabolism of other nutrients already at marginal or low levels in the soil. Nutrient deficiencies or toxicities may predispose seedlings to attack by root disease fungi and are probably responsible for most of the chlorotic foliage observed in the nursery.

Phytophthora root rot occurs in the nursery and is damaging where found. However, activity of *Phytophthora* spp. appears to be limited to areas of the very poorest drainage. Most *Phytophthora*-induced mortality seems to occur in the latter part of the season, in warm, dry weather. Other possibly pathogenic fungi (*Fusarium* spp. and *Pythium* spp.) have been isolated from roots of dead seedlings throughout the nursery. These fungi may act as aggressive pathogens or, more commonly, may infect and hasten the death of trees weakened by some other factor.

Outplanting trials suggest that culling standards for trees with chlorotic foliage at Westfir could be relaxed somewhat. Chlorotic trees with full crowns and root systems seem to survive as well or nearly as well as normal appearing, green seedlings, especially on good sites. Chlorotic trees put on as much growth as green trees, and many rapidly attain normal foliage color when outplanted.

Results of fungicide tests indicate that Banrot and Truban soil drench and root dip treatments do not significantly increase survival or vigor of seedlings in the Westfir Nursery.

RECOMMENDATIONS

(1) Avoid use of poor stock. Do not transplant severely molded, previously heeled-in, or badly injured seedlings. If there are any questions concerning quality of seedlings, consult Forest Insect and Disease Management pathologists. Answers concerning quality of stock can usually be obtained within two days.

(2) Improve soil drainage in the nursery. Survival problems not associated with poor stock in the Westfir Nursery are almost all related to poor drainage. A complete drainage system for the nursery is needed. Avoid planting stock in poorly drained areas.

(3) Avoid unnecessary irrigation. Irrigate only when needed. Avoid a rigid system that may increase drainage problems.

(4) Do not cull chlorotic seedlings if crowns and root systems are full and otherwise healthy. Such trees are suitable for outplanting.

(5) Use of Truban and Banrot fungicides in the Westfir Nursery is not recommended.

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